

Evaluate the effectiveness of fall prevention exercise posture for elderly

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Abstract— Elderly who live in communities, falls are the major cause of unintentional injuries and premature mortality. 21 exercise set postures were developed and designed from the 9-step dance and aerobic workout under the project “Development of Edge Computing and Exercise Platform Using 3D Motion Analysis for Elderly Mobility Disorder Prevention”. The main objective of creating exercise set is fall prevention in elderly people since we believe that the postures able to enhance balance body movement in three muscle parts; upper limb, lower limb, and trunk. However, the effectiveness of exercise posture never be evaluated.

Three physical education experts were invited to provide the score of 20 major muscles of the posture in the exercise set. The muscles were graded based on five likert scale (from strongly focus to strongly poor). The overall result shown that upper limb and lower limb were graded moderate while truck muscle was poor. The average score of each major muscle is also presented in the paper.

Keywords—Fall prevention, Exercise posture, Muscle

I. INTRODUCTION (*HEADING 1*)

As the world's population ages, demographics are shifting on a worldwide scale. The proportion of persons over the age of 65 has tripled over the previous 50 years, and by 2050, older people will make up 25% of the global population. ⁽¹⁾⁻⁽³⁾

Among older persons who live in communities, falls are the major cause of unintentional injuries and premature mortality ⁽⁴⁾. A critical public health issue that impacts quality of life more than anything else and occasionally results in fatal injuries among older persons is falling. Additionally, as people get older and more feeble, their physical and mental changes increase their risk of falling and make them more vulnerable to unintended injuries ⁽⁵⁾.

The optimum levels of exercise for elderly persons have recently been determined by guidelines. The World Health Organization advises older persons should exercise for 150

minutes per week of moderate-intensity aerobic activity or 75 minutes per week of vigorous-intensity aerobic activity, or an equivalent combination of the two ⁽¹⁵⁾.

These guidelines reflect the general perception that "if physical activity were a drug, we would call it a miracle cure because of the vast number of illnesses it can prevent and help treat. ⁽⁶⁾" Despite widespread agreement that exercise is beneficial, research on which exercise characteristics (e.g., type of exercise, intensity, duration, and frequency) are most effective for older adults is mixed. Various types of exercise interventions have been delivered to healthy ⁽⁷⁾ and unhealthy older adults ⁸ in a variety of settings (e.g., community ⁽⁹⁾, residential care homes ⁽¹⁰⁾, private homes ⁽¹¹⁾ and with varying levels of support (e.g., provided by professionals ⁽⁹⁾ or students ⁽¹²⁾).

These interventions aim to improve a variety of outcome metrics, including physical functioning ⁽¹³⁾, falls ⁽¹⁴⁾, and mental functioning ⁽¹⁴⁾. This exercise should be performed in 10-minute increments or longer to reap the most benefits, including cardiorespiratory and muscular fitness ⁽¹¹⁾. Weight-bearing activities can aid in bone and functional health maintenance ⁽¹²⁾. Physical activities also lower the risk of noncommunicable disease, depression, and cognitive decline. Additional health benefits can be obtained by gradually increasing the amount of time spent exercising each week. ^{(15),(12)} The variety of interventions generates inconsistent findings in studies for any type of exercises, anyway the suitable exercise for promoting fall prevention should focus on ⁽³⁾ muscle, lower muscle, trunk muscle and upper muscle. This research are the part of project “Development of Edge Computing and Exercise Platform Using 3D Motion Analysis for Elderly Mobility Disorder Prevention”, that must design exercises that prevent falls using 9 steps as the lower part and aerobic as the upper part of body. But the exercises that are designed must be checked whether they affect the three muscles mentioned above or not. So the aim of this research we will identify to check exercise posture that have been prepared in the project whether it can promote the strength of

the three muscles or not, using of scored from physical exercise experts.

II. LITURATURE REVIEW

A. Mobility Disorder in Elderly

Since there is an increase of number in elderly people in recent year, older people are more vulnerable and likely to fall and this is one issue of mobility disorder. Risk of falls in elderly is a main issue of injury, elderly have more risk of falling than the other ages by 10 times.⁽¹⁶⁾ The physiological loss of the elderly adult may lead to a decrease in balance and an elevated risk of falling, which could become a significant problem for the elderly⁽²⁰⁾ the proportion of oxidatively active muscle fibers that increases with age.⁽²⁴⁾ As humans get aged, neuromuscular deficits (such sarcopenia) may decrease their physical ability and increase their risk of falling.⁽²¹⁾ Elderly adults have a reduction in volume of cells, muscular cells and bone mass. This meant that body have to carry more weight⁽¹⁸⁾ Musculoskeletal system and skeleton in elderly adult have less efficiency due to the changes of joints, bones and muscles. As the result, it would lead to inflexible movement⁽¹⁷⁾ In conclude, it will affect the body of elderly having unbalance movement.

B. Exercise for Elderly

The most effective to prevent fall in elderly is to perform an exercise such as square-stepping. The results showed that the elderly who practiced the square-stepping exercise had greater walking performance, better balance, and greater confidence executing tasks. Furthermore, doing 9 step dances strengthen muscle to improve balance in elderly, also from this exercise will assist in cognitive development since elderly have to remember the pattern of dance.^(38,39) Exercise is critical for preserving your health and wellbeing, but elderly and aging folks may need it even more. Exercise among seniors raises some worries, but the advantages of living an active lifestyle for health much exceed the hazards. Older adults are at a higher risk of falls, which can prove to be potentially disastrous for maintaining independence. Exercise improves strength and flexibility, which also help improve balance and coordination, reducing the risk of falls. The reasons that elderly prefer not doing exercise are poor perception and changes of brain respond owing to aging.⁽¹⁷⁾ A variety of exercise training methods can effectively improve balance, which is a multifactorial attribute. Promoting physical activity in older adults is essential.⁽²⁰⁾ America college of sports medicine suggests elderly adult to have an exercise at least 40 minutes divided into 3 parts including warm up 5 minutes, exercise 30 minutes and cooldown 5 minutes⁽¹⁵⁾ a minimum of 150 minutes per week for instance, 30 minutes per day, five days per week of moderate-intensity exercise or they require 75 minutes per week of intense exercise⁽²⁹⁾ various types of workouts versus control Falls were affected differently by various training types. Balance and functional exercises reduce the number of falls by 24% (8) The effects of balance training in PD indicated that balance training, either by itself or in combined with other training. For instance, strength, joint mobility, or gait training are some methods that can help decrease the

number of falls, also improve physical performance overall and balance control⁽¹⁹⁾.

C. 9 Step dance

The Wii balancing board workout was modified into the nine-square step dance. Similar to the aforementioned board exercise, it is inexpensive and effective. The nine-square step dance exercise, adapted from the Wii balance board exercise, improved the weight shifting in all 3 directions, anterior, posteromedial, and posterolateral directions. This impact on the postural control of overweight. It is a grid of nine identical squares that is 75 cm by 75 cm in size. The exercise requires that individual have to dance from slow to fast music and should dance in time with the music as possible. Dancing patterns of 9 step dances are also fixed to move only forward, backward, left and right. Working out for three days a week, it seems that people who do 9 step dances have greater averages than the control group in the tests for the 3-meter walk and 5-sit-up strength.⁽¹⁵⁾ Also, he nine-square step dance may improve agility, neuromuscular coordination, dynamic balance, and postural adjustment.⁽³⁴⁾ Also, 9 step dance help strengthen the muscle especially lower limb muscle and cognitive development.⁽³⁵⁾

D. Aerobic

The elderly should do aerobic exercise at least five times per week for 30 to 60 minutes each time. and must be done out frequently and consistently at moderate intensity⁽³²⁾ The maximum oxygen consumption capacity can be used to determine the intensity of exercise. Though it cannot be measured while having an exercise Although, elderly should have 40 -80 % of their maximum heart rate. Elderly adult having low capacity should have 40-50 % of their maximum HR while doing an exercise. They recommend that elderly doing their exercise for 15-20 minutes with their 50-70% of their max HR for the best efficiency. It is meant that elderly should exercise on Moderate to Low levels of intensity.⁽³¹⁾ Form other study, there are study about older people doing aerobics and the result seems that walking pace and physical fitness often increased for those who engaged in aerobic activity.⁽³³⁾ Increased aerobic capacity (also known as central adaptations) and metabolic changes in skeletal muscle, such as increased mitochondrial density and capillarization, are facilitated by aerobic exercise.⁽³⁷⁾ It would be more efficient to work out a combination of aerobic and 9 steps dance because aerobic exercise would strengthen upper muscle meanwhile 9 step dances will help lower limb muscle stronger^(37,35).

$$\% \text{ Maximum Heart rate (HR)} = \% (220 - \text{age}) / 100 \text{ -----(1)}$$

From this equation we can observed that there are 4 levels of exercise intensity (33) as seen in Table 1.

TABLE I. INTENSITY LEVEL FOR EXERCISE

Exercise Intensity Level	%HRmax
Low	<57 to <67
Moderate	64 to <76
Vigorous	76 to <96
High	≥96

E. Muscle

Trunk muscular strength (TMS) measurements are linked to factors like static and dynamic balance, functional performance, and falls. Composition and balance of TMS/trunk muscles, functional capability, and falls in older persons. ⁽²³⁾ Elderly people having a different type of exercise, such as balance exercises and elastic-resistance exercises, for 8 weeks. From both types of exercise has a development in various type of muscle. For instance, hip flexor, hip extensor, hip abductor, knee extensor, ankle dorsiflexor, knee flexor and ankle plantar flexor. As a result, the elderly fall rate decreased from 59% to 44.5% in both groups of elderly adults who participated in different types of physical activity. ⁽¹⁶⁾ Reduced balance is related to lower limb muscle strength weakness. To improve balance and lower the risk of falls in later life, increasing muscle strength may be a suitable way. ⁽²⁷⁾ There are additional benefits to lower limb muscular training besides lowering the risk of falls. It depends on type of exercises, for instance sit-to-stand exercise (knee extensor gained), climbing up and down steps/stairs (Hamstrings, Quads, Calves and Gluts gained) and ankle exercises (Gastrocnemius, Soleus, Posterior tibialis, Flexor hallucis longus. gained) reduce the number of falls by 50%, 33% and 25% respectively. ⁽³⁰⁾ Important implications for people using ambulation aids stem from the fact that upper limbs influence frontal plane balance control. ⁽²⁸⁾ With an estimated 10% change in the strength of the upper extremities by having different types of exercise, such as wall push up (pectoral muscles, anterior deltoids, and triceps gained), tend to reduce falls cases by 45%. ⁽³¹⁾ Having a trunk muscle exercise, as demonstrated by exercises with a Swiss Ball show an improvement of the lateral low-back and gluteus medius ⁽³²⁾ would to a reduction of elderly adult falls by 18 % ⁽²³⁾

The result for literature review shown that exercise have more efficiency to reduce falls cases of senior. However, some elderly people with a tendency to deteriorate physical problems and suffering from Alzheimer could not do well on exercise, so they might do the distorted ways of exercise. Exercise properly by utilizing your muscles. It is a strategy or fashion for instructing the elderly. Workout properly.

III. METHODOLOGY

In order to design the posture for elderly's exercise, we have adopted the concept of 9 step dance and aerobic workout. The 9 step dance was selected for lower limb muscles exercise while aerobic workout posture was selected for upper limb muscles. In this research, we combine the 9 step dance and aerobic workout by inviting a group of elderly to choose their preferred postures. From this process, 21 set of exercise postures were proposed. However, in order to make sure that all the major muscles of upper and lower limb will be used for exercise, the research methodology was designed to test the proposed postures. The research framework included 4 parts i.e. posture design, posture selection, exercise set design and muscle assessment as shown in Figure 1.

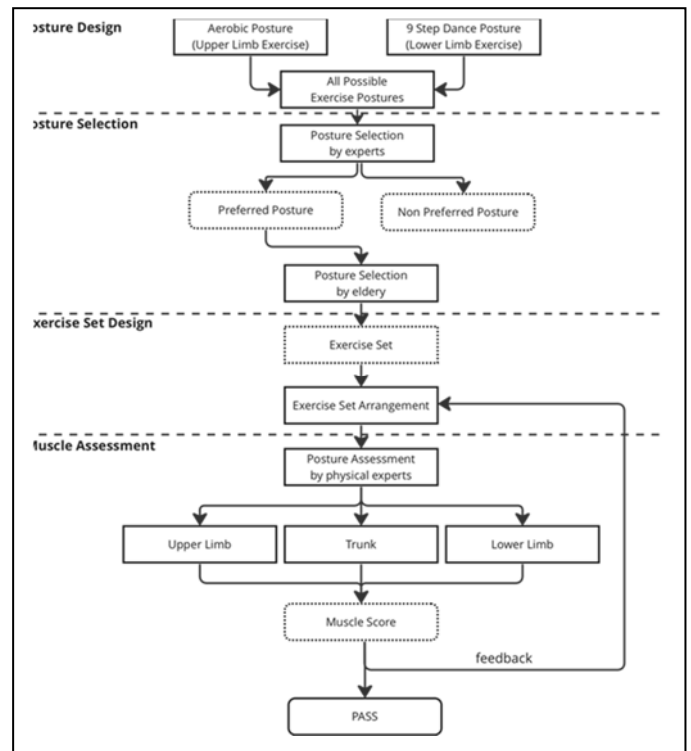


Figure 1 The research framework.

The posture design part focused on finding all possibility of the exercise posture that tend to impact the upper and lower limb major muscle. At this stage, 154 exercise postures were designed. Then, the posture selection part aimed at selecting a set of posture that suitable for elderly exercise. Thus, 10 elderly were invited to test the designed postures. Then, elderly marked the preferred and non-preferred posture regarding to their exercise experience. As a result from this part, 21 postures were selected by the elderly experts. The exercise set design part focused on arranging the proposed postures into an exercise set which match with duration and difficulties. In order to achieve this, an aerobic exercise expert was invited design the exercise set.

Finally, the muscle assessment methodology was proposed for evaluating the effectiveness of the designed exercise set. Three physical education experts were invited to provide the score of each muscle of the posture in the exercise set. The 20 major muscles were categorized in 3 groups i.e. upper limb, lower limb, and trunk. The upper limb included 6 major muscles i.e. Brachioradialis, Biceps Brachii, Triceps Brachii, Deltoid, Pectoralis Major, Trapezius. The lower limb included 4 major muscles i.e. External Oblique, Latissimus Dorsi, Rectus Abdominis, Upper Rectus Abdominis, Lower Rectus Abdominis. The muscles of trunk included 5 major muscles i.e. Gluteus Maximus, Quadriceps, Hamstring, Gastrocnemius.

The result from the muscle testing will be considered as a score of effectiveness of each exercise set. If the score of any major muscles is under moderate score, the exercise set designer team had to improve the unexercised muscle. This process will be recurred until all major muscles of upper and lower limb been used for the exercise.

IV. RESULT

Table 2-4 illustrated the average score of muscle testing grades from three experts. The result divided in three parts: arms muscle, trunk muscle, and legs muscle.

TABLE II. MUSCLE OF UPPER LIMB RESULTS

Muscle of the upper limb	Average Score	Muscle Testing Grades
1. Brachioradialis	4.5	Strongly Focus
2. Biceps Brachii	2.8	Moderate
3. Triceps Brachii	2.8	Moderate
4. Deltoid	4.4	Strongly Focus
5. Pectoralis Major	2.4	Poor
6. Trapezius	3.1	Moderate

Muscle of the upper limb is consisted of six parts. Overall, the result indicated that Brachioradialis (4.5) and Deltoid (4.4) are significantly focused parts while Biceps Brachii (2.8), Triceps Brachii (2.8), and Trapezius (3.1) is considered moderate focus. Only Pectoralis Major (2.4) is marked poor focus. The overall score of upper limb is graded as moderate (3.33) (please see table 2).

TABLE III. MUSCLE OF THE TRUNK RESULTS

Muscle of the trunk	Average Score	Muscle Testing Grades
1. External Oblique	1.6	Strongly Poor
2. Latissimus Dorsi	1.5	Strongly Poor
3. Rectus Abdominis	1.5	Strongly Poor
4. Upper Rectus Abdominis	1.5	Strongly Poor
5. Lower Rectus Abdominis	1.3	Strongly Poor

The muscles of the trunk include five parts of body. The result obviously shown that all parts in trunk muscle are considered significantly poor (see table 3). The overall score of trunk muscular is graded as strongly poor (1.48).

TABLE IV. MUSCLE OF LOWER LIMB RESULTS

Muscle of the lower limb	Average Score	Muscle Testing Grades
1. Gluteus Maximus	2.3	Poor
2. Quadriceps	4.7	Strongly Focus
3. Hamstring	4.3	Strongly Focus
4. Gastrocnemius	2.3	Poor

Table 4 shown result of the lower limb muscle which consisted of four parts. Quadriceps (4.7) and Hamstring (4.3) are both considered as strongly focus from the experts while Gluteus Maximus (2.3) and Gastrocnemius (2.3) are marked as poor. The overall score of lower limb is graded as moderate (3.4).

DISCUSSION

According to the literature, balance exercises such as 9 step dances and aerobic can reduce the number of falls and improve balance control since its support the muscle in

three parts: upper limb, lower limb, and trunk muscular strength. However, the result from three physical education experts obviously shown that dance posture which designed in this study lack of movement in trunk muscle part (average score is 1.48). Therefore, exercise designer should particularly add on the posture that improve External Oblique, Latissimus Dorsi, Rectus Abdominis, Upper Rectus Abdominis, and Lower Rectus Abdominis. The recommended exercise posture can be hip flexor, hip extensor, hip abductor, knee extensor, ankle dorsiflexor, knee flexor and ankle plantar flexor. Meanwhile, upper limb and lower limb are overall considered as moderate grade where Pectoralis Major, Gluteus Maximus, and Gastrocnemius are poor grade. There is no recommended to add any posture for upper limb and lower limb exercises since it difficult to match with dancing context. However, we propose that the elderly may consider workout for their own alternative exercise such as on push-up, seated calf raise and reverse lunges.

V. CONCLUSION

This study evaluates the effectiveness of 21 exercise set which designed from the 9-step dance and aerobic workout. Three physical education experts were invited to provide the score of upper limb, lower limb and truck muscle of the posture in the exercise set. Even upper and lower limb evaluated as moderate grade we still recommend elderly workout extra more on Pectoralis Major, Gluteus Maximus, and Gastrocnemius part. While truck muscle posture should be added on exercise set. The limitation of this study is number of physical education experts and duration. Future work will more focus on the effect of exercise implementation on elderly fall rate.

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